DOCUMENT RESUME

ED 475 477 SE 067 595

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TITLE	Technology Integration in an Elementary Science Classroom: Its Impact on Teaching and Learning.
PUB DATE	2003-03-00
NOTE	9p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Philadelphia, PA, March 23-26, 2003).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	*Educational Technology; Elementary Education; *Elementary School Teachers; Grade 4; Grade 5; Interdisciplinary Approach; Learning Strategies; *Problem Solving; Science Education; Space Sciences; Teacher Student Relationship; *Teaching Methods

ABSTRACT

The purpose of this study was to explore the following questions: (a) what practice, if any, develops in the elementary science classroom to nurture development of technology as an imaginative extension of the learning environment; (b) how does an elementary teacher's practice change as technology is integrated into the science curriculum, how do the students' practices change, and how do these changes impact each other; and (c) what are "powerful uses" of technology that may emerge in the elementary science classroom, what structures should be in place to support their development? To answer these questions, sustained time was spent in a 4th/5th grade classroom as a participant researcher as the class investigated the topics of the solar system and space exploration. Data gathered included pre- and post-surveys of the teacher and students, audiotaped interviews with the students and teacher, focused observation, and selective videotaping of events in the classroom. It is concluded that classroom instruction and learning were enriched through the integration of computers in support of the science curriculum. (Author/KHR)

Technology Integration in an Elementary Science Classroom: Its Impact on Teaching and Learning

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A paper presented at the National Association for Research in Science Teaching annual meeting, Philadelphia, PA, March 2003

Session # 201809

ABSTRACT

The purpose of this study was to explore the following questions: a) what practices, if any, develop in the elementary science classroom to nurture development of technology as an imaginative extension of the learning environment; b) how does an elementary teacher's practice change as technology is integrated into her/his science curriculum? How do the students' practices change? How do these changes impact each other; and c) what are 'powerful uses' of technology that may emerge in the elementary science classroom? What structures should be in place to support their development?

To answer these questions, the author spent sustained time in a 4th/5th grade classroom in the role of participant researcher as the class investigated the topics of the Solar System and Space Exploration. Data gathered included pre- and post-surveys of the teacher and students, audiotaped interviews with the students and teacher, focused observation by the author, and selective videotaping of events in the classroom. Classroom instruction and learning were enriched through the integration of computers in support of the science curriculum.

INTRODUCTION and OBJECTIVES

Instructional technology has the capacity to enhance teaching and learning in the classroom. Through technology, the classroom community can explore the world outside the school, communicate with other students, correspond with scientists and researchers, collect and interpret real data about real phenomena, share findings, etc. In short, computers can be used in support of inquiry in science teaching, when inquiry is defined as the opportunity to "find solutions to real problems by asking and refining questions, designing and conducting investigations, gathering and analyzing data, making interpretations, drawing conclusions, and reporting findings" (Krajcik, Blumenfeld, Marx, & Soloway, 2000).

The ubiquity of computers in our culture and economy places increasing pressure on our schools to 'produce' students who are familiar with their use. While computer skills are recognized as beneficial for future workers (ISTE, 2000), that is only one reason computers are being placed in classrooms. Instructional technology, including, but not limited to, computers, can enhance children's learning and augment teachers' practice. Though issues of equal access to technology are crucial, how we use computers that have been placed in the classroom is also of critical importance. Educators need to concentrate on learning how to use technology in context; matching hardware and software combinations to the needs and abilities of learners and to the instructional objectives (Kent & McNergney, 1999).

Research Questions

This project was created in the form of a qualitative case study in which I took on the role of a participant researcher/observer in an intermediate classroom. My focus was on the practices which emerged as teacher and students interacted with technology while investigating the science topics of astronomy and space exploration. My specific research questions were:

1. What practices, if any, develop in the elementary science classroom to nurture development of technology as an imaginative extension of the learning environment?
2. How does an elementary teacher's practice change as technology is integrated into her/his science curriculum? How do the students' practices change? How do these changes impact each other?
3. What are 'powerful uses' of technology that may emerge in the elementary science classroom? What structures need to be in place to support their development?

In essence, these questions allowed me to closely observe, and then describe in detail, what occurred in the classroom; to examine how the students and teacher interacted with the technology, with each other, with the science topic, and, to some extent, with me. Then, the task was to describe their practices and identify any changes that may have occurred over time. To some extent, I hoped to actually see these changes over the course of my time in the classroom, but I also asked the teacher and students to reflect on their use of technology, within the topic of science, but also in other curricular areas. In addition, I attempted to identify any utilization of technology which had a pronounced effect on the teaching and learning that happened in the classroom. This required that I be able to judge what occurred in this area, both as an impartial observer, but also as a community member. If these 'powerful uses' emerged, then the hope was that any structures of the classroom that helped to develop them would be apparent.

THEORETICAL APPROACH

Community of Practice

I approached this research partially as an exploration of a community of practice. Wenger (1998) defined a community of practice as "collective learning (that) results in practices that reflect both the pursuit of our enterprise and the attendant social relations...a kind of community created over time by the sustained pursuit of a shared enterprise" (p.45). Wenger (1998) also makes a case for the social nature of learning, even though "our institutions...are largely based on the assumption that learning is an individual process" (p.3). The classroom community is one which is defined by the participants working together as they develop a shared repertoire. This community "includes routines, words, tools, ways of doing things, stories, gestures, symbols...actions, or concepts that the community has produced or adopted in the course of its existence, and which have become part of its practice" (Wenger, 1998, p.83).

Complexity Theory

Classrooms can also be viewed through the lens of complexity theory. Waldrop (1992) examines a wide range of questions, both sociological and scientific, using the concepts of complexity. The classroom fits Waldrop's description of a complex system in that:

- a great many independent agents are interacting with each other in a great many ways;
- groups of agents are seeking mutual accommodation and self-consistency and somehow manage to transcend themselves, acquiring collective properties...of thought and purpose that they might never have possessed individually; and
- it is adaptive, i.e., the community doesn't passively respond to events, but rather turns them to its advantage.

Waldrop states that these complex systems have acquired the ability to bring order and chaos into a special kind of balance. The successful and dynamic classroom exists on the edge of order and chaos. If a room is too ordered, neat, planned, and predictable, independent learning and creativity can be stifled. On the other hand, a chaotic and completely unpredictable classroom doesn't allow much to be accomplished at all.

Morowitz (2002) focuses on the idea of emergence as crucial to the study of complex systems. It is the emergent properties of a complex system which cannot be predicted from the individual properties of the system, but are properties of the whole as a result of the interaction of the parts. In his book, Morowitz (2002) provides numerous examples of emergence in the natural world, but also explores human social phenomena such as language and urbanization. Emergence, attempting to generate properties of the whole by understanding its parts, is defined as the opposite of reduction, which is the attempt move from the whole to its parts. Reductionism has been the historical perspective of science, but the more recent framework of examining the world through the lens of complexity science and emergent properties can aid in our understanding of a wide range of phenomena.

Technology in Support of Science in the Elementary Classroom

The *National Science Education Standards* (NRC, 1996), the *National Educational Technology Standards for Students* (ISTE, 2000), and the *AAAS Benchmarks for Science Literacy* (1993) all encourage the use of technology in the classroom, especially in support of scientific inquiry. Technology fosters an active environment where students not only solve problems, but also can find their own science problems to explore. Technology has the capacity to create new opportunities for authentic instruction by bringing real-world problems into the classroom for students to scientifically investigate; providing scaffolding and tools to enhance learning; giving students and teachers more opportunities for feedback, reflection, and revision; building local and global communities; and expanding opportunities for teacher learning (NRC, 2000).

Although inquiry can be done in the classroom without the help of technology, learning technologies extend the range of questions that can be explored, the kinds of information that can be collected, the variety of data representations that can be displayed, and the products that students can create to demonstrate their learning. Technology tools allow students to collect information about their questions via the World Wide Web, make graphs and tables as a way of interpreting and displaying data, and to communicate their findings to an audience, perhaps through multimedia presentations (Krajcik et al., 2000).

Technology should give a significant educational advantage, be affordable, networked, and portable. For successful implementation, curriculum goals and materials, assessment policies, and teacher development must shift as well. It is not the equipment in the classroom, but how the equipment is used that can make a difference in student understanding (Wiske, 2000).

The role of the teacher is crucial in the implementation of technology in the classroom, as well as in the continued maintenance of inquiry-driven science instruction. It is the teacher "who can set the stage in the classroom for students to engage the ideas of others and thereby fosters the kind of thoughtful, reflective discussion that characterizes learning" (Feldman, Konold, & Coulter, 2000, p.17). However, "there is a conspicuous lack of attention to the complexities and intricacies of how classroom teachers actually integrate technology in their teaching" (Zhao, Pugh, Sheldon, & Byers, 2002, p.483). This is why, in addition to examining the impact on student learning in the elementary science classroom, I have chosen to place equal emphasis on the teacher as she worked to use the computers in her classroom to their fullest potential.

NUTS AND BOLTS

Research Setting

Bayside Elementary, in a coastal community of a Pacific Northwest state, is a school of 250 students in grades K through 5, with approximately 25 staff. The population is predominantly white and of medium socioeconomic status (25% of students receive free or reduced lunch). The surrounding neighborhood is very established, with many current students being descendants of Bayside alumni.

The classroom in which I did my research is a 4th/5th grade multiage environment. For many years, Bayside intentionally maintained multiage classrooms. Recently, that practice ended in the face of parent opposition. However, this year the student numbers were such that this arrangement was necessary. The classroom teacher, Belinda Knudson[1], was always quite comfortable in the multiage setting, and was satisfied with this arrangement. Six of the 24 students were 4th graders who were chosen on the basis of their anticipated ability to mesh with the 5th graders academically and socially. The class was treated as a whole, with the only exception being the infrequent departure of the 4th graders to study state history in another 4th grade classroom.

I chose this classroom and teacher for my research for three reasons. First, I am familiar with Belinda Knudson professionally as I have worked at Bayside in my capacity as an intern supervisor from the local regional university. Last year when I was looking for a place to do science education research, I immediately thought of Belinda, as she is the only intermediate teacher at Bayside who consistently teaches science. Second, I am familiar with Bayside personally as my son was previously a student there. Third, Belinda Knudson is a district-funded participant in the local Gates Grant, which means that she has eight high-speed Internet computers in her classroom. However, as she is a district-funded participant, she has received

[1] All place names and people are confidential and protected by pseudonyms.

only equipment and very little training. This has frustrated Belinda, who told me last year that she was comfortable with the technology, but that she felt she and her students were not benefiting as much as they could from it. So, as I believed that I could provide some insight and experience with the science content and technology for her, and her classroom would be a good match for my research goals, we decided to embark on this project together.

Research Methods

For this research, a qualitative case study format was followed. I spent two to three full days per week in the classroom over a period of four months. A case study design is employed to gain an in-depth understanding of a situation and meaning for those involved. As Merriam (1998) states "the interest is in process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation" (p.19). Usually, case studies are the best strategy when "how" research questions such as mine are being explored. Also, I as the investigator had minimal control over what happened in the classroom, and wished to investigate a contemporary phenomenon in its real-life context where the boundaries between the phenomenon and the classroom context are not always clear (Yin, 1994).

However, I did take on the role of participant researcher. The classic definition of the participant researcher is that of the investigator engaging in the social context of the phenomenon being studied, but being only partially involved so that s/he can function as an observer as well (Merriam, 1998). The method of participant observation has deep roots in anthropology. DeWalt & DeWalt (2002) define it as "a method in which a researcher takes part in the daily activities, rituals, interactions, and events of a group of people as one means of learning the explicit and tacit aspects of their life routines and culture" (p.1). Participant observation can enhance the quality of data obtained as the researcher is involved in all of the day-to-day functions of the community, and is familiar with all participants and common occurrences. This can also aid in data interpretation, whether the data are obtained through participant observation, or by other methods. Being a participant researcher also has an advantage in that it allows the researcher to formulate new research questions grounded in 'on the spot' events.

SIGNIFICANCE

It can be difficult to evaluate the impact of technology in schools. The school itself is an imperfect research environment with many confounding variables. Implementation varies from class to class, teacher to teacher, and school to school; hence the case study structure for this research. Also, very few tests measure gains which can be made through technology use, such as "sophisticated problem solving, writing, collaborative learning, global awareness, independence and efficacy, engagement and motivation, as well as in students' specific technology skills" (Herman, 1994, p.150). For this project I collected primarily implementation data along with some outcome data.

Innovative technology is more likely to be integrated into classroom instruction if the teacher is highly reflective about his/her teaching practice and is able to consciously use the technology in a way that is consistent with his/her pedagogical beliefs (Zhao et al, 2002). For this project a series of interviews was conducted with the classroom teacher in order to explore her beliefs and to encourage her to reflect upon her pedagogical approach and technology's role in her instruction. One of the stated goals of this project was to view technology as a means to an end, rather than an end in itself, so that technology was used in support of the science instruction, rather than technology being the primary focus. Zhao et al (2002) also found that classroom implementation of technology was more effective in this type of environment.

Students in this project often utilized information acquired from the Internet. Having this incredible array of information available to students is a tremendous opportunity. However, students need to be taught to filter and *critically* engage with resources they find, to develop the ability to discriminate between fiction and fact, and to determine the worth of data (Oseas, 2000).

FINDINGS

In this research, I gathered: a) copious field notes from focused observation over a substantial period; b) written pre- and post-surveys about technology use and comfort for both teacher and students; c) audiotaped and transcribed interviews with teacher and students; and d) selective digital photos and video of events in the classroom. I am currently engaged in evaluating the large amount of data acquired, but a few findings stand out now.

All students were quite comfortable using the classroom computers for research, publishing, data analysis, communication, and presentations in the area of science. Most had been working with computers at school for many years, and all but two students had a computer at home. Students reported using computers for a wide range of activities at home, such as homework, e-mail, and games. In the classroom, we found that it was not imperative that each student have access to his/her own computer at all times. In fact, most students reported that they worked better in pairs or trios when using the computer, which was confirmed by my observations. This classroom had eight computers, and students could go a short distance to the library for more if needed.

However, all students had some degree of difficulty with discerning the quality of the information they researched on the Internet. The evaluation of information became a focus throughout the project, as we helped students to gather and analyze data that at times were unclear or conflicting. Some students also struggled with maintaining focus as they searched the Internet for information. Often, students would click on any hypertext link that appeared on a web page, regardless of its relevance to the topic. Still, the ability to quickly access information from a wide range of areas clearly enhanced the learning that went on in the classroom.

The curricular area, astronomy, was one well suited for the use of computers in instruction. The school library, though well equipped, had only four books on the topic, two of which were about the astronaut, Sally Ride. Obviously, the students were able to find far more information on the internet than they did in books. Students also said in interviews that they were more satisfied with using the computers for research as they could find data more easily using searches. Astronomy is a topic which is growing and changing on a daily basis. Using computers allowed the students to find current information, often from the primary source. Though we also learned through hands-on lessons such as solar system, season, and lunar phase modeling, and moon observation, there are not that many good physical inquiry lessons available in the area of astronomy for children of this age. The incredible array of data available through computers made this topic feasible for students of intermediate age.

Students used computers primarily for research, data analysis, and presentation. After learning some basics about the solar system, pairs of students found physical data about one planet, and shared it with the class through a polished travel brochure created with a publishing program. In small groups, students learned about the motion and scale of the planets through the software program Starry Night. Then, in pairs or trios, students investigated human exploration of space, and prepared PowerPoint™ presentations for their colleagues. As a final project, each student chose an individual science research topic to investigate in order to prepare a presentation (either physically or via the computer). Guidelines for all presentations were decided upon by the entire class, rather than by the classroom teacher. Students were quite adept at deciding what elements needed to be included for an effective presentation.

The classroom teacher was already familiar with computers as she was a Gates Grant recipient, resulting in her classroom receiving computers and other equipment. She still believed at the end of the project that there was room for improvement in her teaching using technology. In addition, Belinda is a constructivist teacher, in that she believes her role as the teacher is that of a guide for the students as they work to make sense of the world. She also is willing to spend large amounts of time on a single curriculum area so that the children can become thoroughly familiar with it, rather than rushing through a series of topics in a superfluous manner. Belinda already had a strong interest in science instruction before this project, and in fact was the only intermediate teacher in the building who consistently made time in her day for science. Therefore, she was more than interested in participating in this project from the very beginning. However, she reported that she felt her science teaching competence grew with the increase in computer use in her classroom. Belinda stated that she felt her role change even more from that of the leader of the classroom to more of a facilitator position, and that she had hoped that change would occur. This is in keeping with Westreich (2000), who stated that roles can shift as the teacher becomes more of a guide as students work with their own data, compare results, and make conclusions.

It is important to point out that the Belinda is continuing to work on increasing the role of computers in her classroom in all curricular areas. Though the Gates Grant requires a certain percentage (80%) of instructional time be spent using the computers, she is very focused on making sure that that time is well spent and pedagogically grounded. This project, while also exploring some of my research questions, also helped her to explore her options in the use of technology in the classroom. Belinda persists in this endeavor, and I also continue to communicate with her on a follow-up basis.

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Note: Student work from this project is available on the Web

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